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Avatars, People, and Virtual Worlds: Foundations for Research in Metaverses

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Abstract

Metaverses are immersive three-dimensional virtual worlds in which people interact as avatars with each other and with software agents, using the metaphor of the real world but without its physical limitations. The ubiquitous availability of high speed Internet access has spurred enormous interest in virtual worlds like Second Life and World of Warcraft, both in terms of user gaming and as a new technological platform for global virtual collaboration. These environments have potential for richer, more engaging collaboration, but their capabilities have yet to be examined in depth. Of particular interest in this paper is the use of metaverses for virtual team collaboration. We develop a conceptual model for research in metaverses that is based on five key constructs: (1) the metaverse itself, (2) people/avatars, (3) metaverse technology capabilities, (4) behaviors, and (5) outcomes. We present an in-depth characterization of metaverse technology capabilities from a socio-technical view that recognizes the potential for variation in emergent interaction and in outcomes. Example propositions and a discussion of key issues and challenges show how the model can be used to further research and practice in virtual teams in the context of these new environments.

Keywords: *metaverses, virtual worlds, virtual teams, collaboration.*

Avatars, People, and Virtual Worlds: Foundations for Research in Metaverses

1.   Introduction

Metaverses are immersive three-dimensional virtual worlds (VWs) in which people interact as avatars with each other and with software agents, using the metaphor of the real world but without its physical limitations. This broad concept of a metaverse builds on and generalizes from existing definitions of VWs (e.g., Bainbridge, 2007) Metaverses provide virtual team members with new ways of managing and overcoming geographic and other barriers to collaboration. These environments have potential for rich and engaging collaboration, but their capabilities have yet to be examined in depth.

Metaverses go beyond the tool metaphor of information technology to being a model of the real world and an extension of users as actors (Sotto, 1997). Metaverses exemplify this concept by allowing for a wide range of activities, including play, information seeking, team interaction, and commerce. Our specific interest is in the use of metaverses by members of virtual teams, which we define as groups of people who are geographically and/or organizationally dispersed and who rely on collaboration technologies to carry out tasks (Dubé and Paré, 2004, Zigurs, 2003). Studies of virtual teams have provided important knowledge for both researchers and practitioners on phenomena related to communication and information sharing (e.g., Majchrzak and Malhotra, 2003, Pinsonneault and Caya, 2005, Powell et al., 2004) as well as the challenge of overcoming limits to location and dispersion (e.g., Cousins and Robey, 2005, Jin and Robey, 2008, Robey et al., 2003, Sotto, 1997). The context of metaverses allows for thought experiments on entirely new ways that virtual team members might work together. For example, globally-dispersed team members can create avatars and have them interact "face-to-face" in a VW through unique representations with the use of three-dimensional artifacts that can be created instantly to represent ideas, values, objects, or feelings. The metaverse context creates an opportunity to advance knowledge on virtual teams and our thinking on technology capabilities. The research gap that needs to be filled is in our understanding of how metaverses are different from traditional virtual collaboration and what theories are relevant for enhancing understanding of behavior, management, and technology phenomena in this environment.

The potential for contribution to knowledge lies in several areas. First, the study of virtual teams in a metaverse environment can contribute to a deeper understanding of virtual collaboration and teamwork in traditional contexts. Second, a theoretically-defined set of technology capabilities can show how metaverses are different from other kinds of environments and how their uniqueness might enhance the functioning of virtual teams. Third, a clear insight into metaverse capabilities and use can lead to recommendations for the continuing design of advanced technologies for virtual team collaboration. Our overall goal is to enhance research and practice for virtual teams working in a metaverse environment. We present a conceptual model for understanding metaverses and develop a set of recommendations for research in this new area. Our proposed model is different from earlier models of group support and collaboration technologies because it accounts for the unique technology capabilities of and behaviors in metaverse environments. Organizations and academic institutions that are exploring the use of metaverses can benefit by seeing how team interaction might be enhanced. Virtual team managers can benefit by being aware of the basic characteristics of this new environment and how its technological capabilities have potential to provide a richer form of interaction for virtual teams. Researchers can benefit from the foundation for future research in terms of constructs, propositions, and research challenges.

The next section presents a conceptual model that we elaborate based on current knowledge and relevant theories and constructs. The subsequent section presents example propositions developed from the model that contribute to defining future research, followed by discussion of challenges and opportunities. The paper concludes with implications of the proposed model.

2.   Model for Metaverse Research

A model for metaverse research must include both the technology capabilities of metaverses and the social interaction that takes place in the metaverse environment. Therefore, we take an interactionist, or socio-technical, view that presents metaverse technology capabilities as a starting point and shows

how on-going social interaction affects and changes those capabilities. This means that the model is neither deterministic nor technology-centric, but recognizes explicitly the role of human actors and the multiple potential paths that they can take through interaction with each other and with technology. This approach is consistent with the logic of adaptive structuration theory, which argues that advanced information technologies, of which metaverses are an example, trigger adaptive structurational processes that can lead to changes in the rules and resources that the technology and/or group originally provide (DeSanctis and Poole, 1994). Adaptive structuration theory takes as a core concept the interplay between technology and social process, illustrating how different outcomes can develop from the same starting point, and our model is based in that tradition.

The concepts of tailorable technologies (Germonprez et al., 2007) and dynamic switching (Mowshowitz, 1997) also support the idea that social structures or interaction in metaverses can affect and change metaverse technology capabilities. Our model treats technology capabilities as dynamic, representing a starting point that can change through interaction in the metaverse. Our notion of dynamic capabilities is consistent with Mowshowitz's (1997) definition of virtuality as using dynamic switching to match satisfiers with problems, where the dynamism is the key to what virtuality can provide.

Figure 1 presents a conceptual model of five interacting components that we argue are fundamental for understanding teamwork in a metaverse environment: (1) the metaverse itself, (2) people/avatars, (3) metaverse technology capabilities, (4) behaviors, and (5) outcomes. The circular relationships within the metaverse and with outcomes illustrate the on-going social interaction that affects and is affected by metaverse technology capabilities. The arrows that show this circular relationship are intended to represent interplay among these constructs and not a unidirectional causality. In addition, there is no predetermined bias as to the nature of outcomes, since both positive and negative outcomes can be expected.
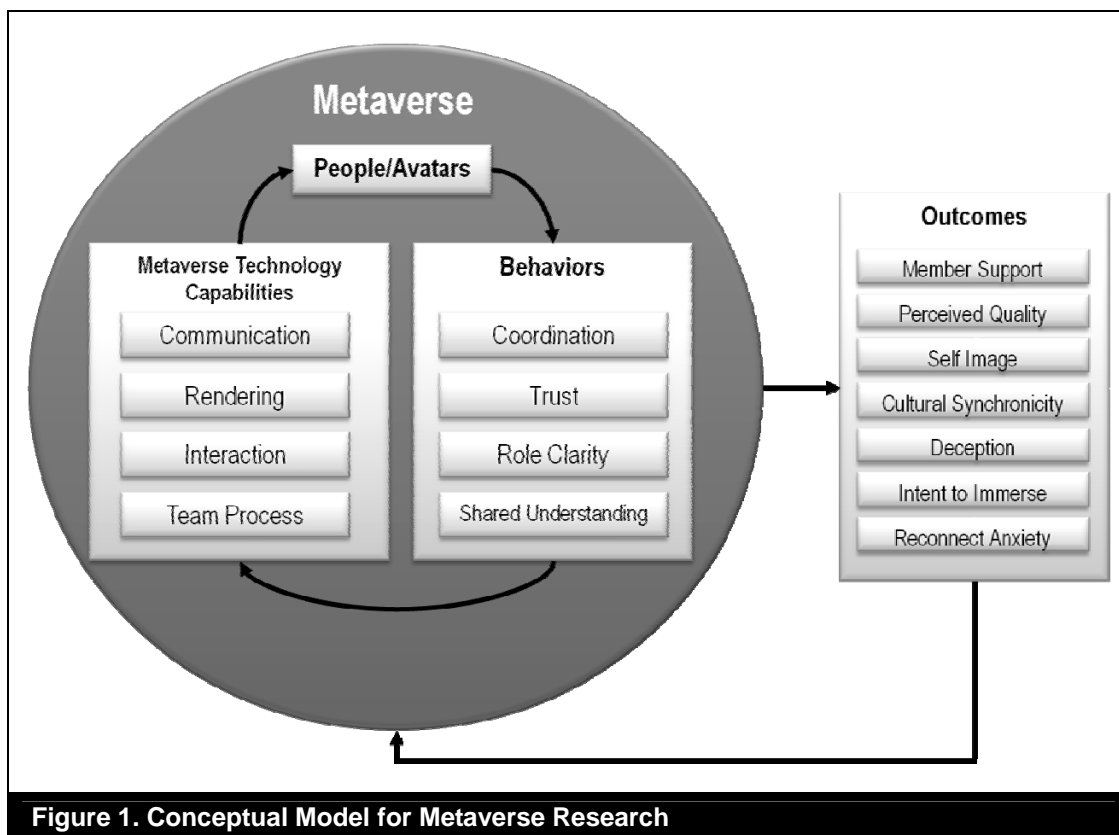

Figure 1. Conceptual Model for Metaverse Research

The following sections discuss each component of the model. The first two components – the metaverse and people/avatars – set the context for interaction and how people represent themselves. The remaining three components – metaverse technology capabilities, behaviors, and outcomes – characterize the relationships among key concepts in the interaction and emergent results.

2.1. Metaverse

The first component of our model is the *metaverse* itself. A specific instantiation of a metaverse is a virtual world, including what others refer to as virtual spaces or virtual world environments. With advancements in technological capabilities, VWs have grown into environments that are capable of supporting effective interaction (Schroeder et al., 2006, Sempsey and Johnston, 2000). Metaverses are configurable with respect to communication and appearance capabilities, which allows team members to interact in different ways to support team collaboration (Kahai et al., 2007). Increasingly, metaverses are a common platform for social, educational, and business activities, and numerous organizations have a presence in VWs. Appendix A provides basic background on metaverses, including current examples of VWs.

2.2. People/Avatars

People are the users or team participants who are represented in a metaverse. People are represented by and are in control of *avatars*, including avatar appearance and behavior. An *avatar* is defined as a user-created digital representation that symbolizes the user's presence in a metaverse (Bailenson et al., 2005). The concepts of interest in relation to people/avatars in a metaverse are: representation, presence, and immersion. Table 1 defines these concepts, and the rest of this section presents a historical review of their development and treatment in existing research.[1]

Table 1: Concepts of Interest Related to People/Avatars in a Metaverse	
Concept	**Definition**
Representation	Appearance of avatars and their environment and the ways in which avatars and the environment interact.
Presence	The sense of being in an environment (Steuer, 1992).
Immersion	Degree to which people perceive that they are interacting with their virtual environment rather than with their physical surroundings (Guadagno et al., 2007).

People appear and act in a metaverse through their avatars, which are representations of themselves. Representation refers not only to the appearance of avatars and their environment (which may include realistic objects such as desks and office furniture or unrealistic objects such as talking animals), but also to the ways in which avatars and the environment interact. Research suggests that the appearance of avatars and the environment, along with their interactions, can affect people's sense of presence in the metaverse (Biocca et al., 2003, Blascovich, 2002, Lombard and Ditton, 1997).

The concept of presence has evolved through years of study, and a variety of presence-related terms with overlapping definitions has emerged (Kalifa and Shen, 2004, Lee, 2004, Swinth and Blascovich, 2002). Presence was initially defined rather simply as the sense of being in an environment, and the term telepresence was used to describe the extent to which people felt present in a mediated environment as opposed to the physical environment (Steuer, 1992). Others defined presence more broadly and used the term to describe the extent to which other living and synthetic beings exist in a virtual reality environment and appear to react to human representations (Heeter, 1992). Lombard

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[1] The terms "virtual reality" and "virtual world" have both been used inp the literature (Blascovich et al., 2002, Heeter, 1992, Lombard and Ditton, 1997, Steuer, 1992). We consider virtual reality to refer to systems that incorporate a variety of extra-peripheral devices, such as goggles, sensor gloves, and other haptic devices that enhance the sense of immersion inside the portrayed environment. In contrast, our concept of a metaverse (and its specific instantiation in a virtual world) refers to systems that do not incorporate additional peripheral devices as part of an individual's participation in the environment.

and Ditton (1997, p. 8) recognized the important role that technology played in creating a sense of presence when they defined presence as "the perceptional illusion of nonmediation." In this use, nonmediation means that the technology provides such an engaging experience that the technical interface components of the VW are rendered essentially invisible due to the intensity of interaction. The VW transforms itself into a social entity rather than a technical artifact.

As technologies matured and became more widely available, more people joined VWs, and the understanding of presence evolved to include the sense of being with and interacting in symphony with others in a virtual place (Slater et al., 2000). This evolution led to the emergence of another term, social presence, which was defined as a "sense of being with another in a mediated environment" (Biocca and Harms, 2002, p. 10). Biocca and Harms (2002) elaborated social presence as a continuum that ranged from an awareness of the presence of others, which they termed copresence, through higher levels of social interaction that resulted in interdependent behavior. Others defined copresence differently as both a *way* of being with others (a technology dimension) and a *sense* of being with others (a social dimension) (Zhao, 2003). Still others explicitly identified social presence and copresence as equivalent terms (Bailenson et al., 2005, Shen et al., 2006). To date, there is no clear consensus on definitions of the concepts related to presence, and some researchers now use presence as an over-arching concept that encompasses telepresence, copresence, and/or social presence (Kalifa and Shen, 2004, Lee, 2004, Swinth and Blascovich, 2002).

Despite this lack of consensus, however, research has shown that as technology improved, people experienced higher levels of presence to the extent that they reported becoming "immersed" in virtual environments (Guadagno et al., 2007). In early studies of virtual reality, immersion was defined as the perception of being enveloped in the virtual reality, where virtual realities "perceptually surround the individual" (Blascovich et al., 2002, p. 105). Subsequent researchers defined immersion as the degree to which participants perceived that they were interacting with their virtual environment rather than their actual physical surroundings (Guadagno et al., 2007). These conceptions of immersion, with their focus on perceptional substitution of virtual reality for the real world and the lack of emphasis on participant interaction, lend themselves more to the realm of virtual reality environments than VWs.

The key theme that runs through these different conceptualizations is the idea of realistic interactions with responsive representations in contextually accurate settings. The ultimate goal of many VWs is to create a sense of shared space (Lanier and Biocca, 1992), and researchers have recognized the importance of presence as a measure for that experience (Biocca and Harms, 2002, Lombard and Ditton, 1997). How, then, can people use their avatars to create that interaction in the shared space? Individuals typically have control over their avatar's appearance and use of communication channels (Bainbridge, 2007, Ives and Piccoli, 2007, Kahai et al., 2007). People can reflect their own unique style and personality through modifying their avatar's body style and clothing (see Appendix A for examples of avatar representations). Anonymity in the VW is maintained, since users either create names for their avatars or select from a limited set of available names. Newer VWs give individuals considerable latitude in building complex in-world (i.e., inside the VW) representations for themselves and their environments (Bainbridge, 2007). Capabilities like scripting, graphics tools, and the ability to import objects from outside the metaverse allow people to incorporate contextual cues that can enhance the quality of interaction (Blascovich et al., 2002). The variation in how people select and customize in-world representations raises questions about how those choices might affect avatar-to-avatar interaction in the context of virtual team collaboration.

The extent of realism in representation via avatars, environment and interaction has been shown to affect presence. Blascovich (2002, p. 26) defined behavioral realism as "the degree to which others appear to participants to behave as those participants have been socialized to expect others to behave (e.g., in face-to-face interactions)." Beyond the obvious visual appearance dimension, a key contributor to realistic behavior is the avatar's ability to interpret verbal and nonverbal cues from the representation of others and to react with appropriate responses (Blascovich et al., 2002). The more realistic the representation, the greater is the sense of presence. Conversely, when the environment or the interactions are out of consonance with expectations, people report lower ratings of presence

(Guadagno et al., 2007, Lombard and Ditton, 1997). Thus, it is important that an avatar's appearance and interactions be consistent and understandable within the context of the VW's purpose.

Representations that allow for more vivid or engaging interaction have also been characterized as establishing greater presence (Lombard and Ditton, 1997, Steuer, 1992). Behaviors that contribute to being engaged include interacting with other avatars, interpreting and organizing information gleaned in the VW, making decisions and acting on those decisions, and all the other behaviors a person would normally perform in an out-world (i.e., outside the VW) group of people (Jacobson, 2002, Lombard and Ditton, 1997, Rice, 1992). Steuer (1995) identified breadth and depth of sensory inputs to detect such behaviors as key determinants of how vivid an experience is considered to be. VWs that offer broader ranges of communication capabilities are considered to be socially richer and, thus, establish higher degrees of presence (Lombard and Ditton, 1997, Rice, 1992). Specifically, avatars might be able to interact with each other via chat connections, have optional audio channels, and "see" each other.

In sum, the sense of presence is affected by a number of representation factors that interact to shape a person's level of engagement. Understanding these factors and recognizing how they instantiate within a particular VW to support or detract from the VW's intended purpose can help designers and users of VWs get the most from their experience. The discussion thus far has shown how avatars represent people within the VW, the key concepts related to that representation, and the impacts on presence. The next component of our model – metaverse technology capabilities – sets the stage for what is possible in VWs and how we think about those possibilities, from the perspective of the technology infrastructure provided.

2.3. Metaverse Technology Capabilities

We define a *metaverse technology* as a set of capabilities for communication, rendering, interaction, and team process. The concept of technology as a set of capabilities appears in a variety of ways in the literature, for example, capabilities of office automation technologies (Gutek et al., 1984) or capabilities for leveraging enterprise-wide information technology (Bharadwaj, 2000, Henderson and Venkatraman, 1999). We base our notion of capability on its original dictionary meaning, in which capability is the inherent potentiality of being developed, i.e., a "feature or faculty capable of being developed."[2] Thus, in our context, metaverse technology capabilities provide potential features – both current and yet to be discovered – that can be developed for specific functionalities. Capabilities are dynamic and represent a starting point that can change through interaction in the metaverse. The basic idea of technology capabilities and change through interaction is consistent with prior research on groupware and collaboration technologies (Carte and Chidambaram, 2004, DeSanctis and Poole, 1994).

The concept of metaverse technology as a set of capabilities is included in our model for three reasons. First, technology plays a key role in virtual teams in that it is the environment through which people carry out tasks and activities. Second, VWs and the interactions of people and technology are engendered through the technology capabilities of the metaverse. Finally, existing classifications of technology capabilities do not yet account for metaverses and their unique characteristics. The taxonomic perspective that is the basis of many technology classifications cannot provide a complete picture of metaverse environments, given that these environments present a different kind of context (Zigurs and Khazanchi, 2008). The capabilities approach allows us to take a more flexible view that has potential to incorporate new features as technology evolves. Furthermore, as noted earlier, we do not treat these capabilities as fixed capabilities, but instead as being dynamic and evolving as avatars interact in the metaverse.

The following sections examine metaverse technology capabilities in each of the four areas of communication, rendering, interaction, and team process. For each area, we review relevant concepts from existing research and show how those concepts can be extended in metaverses, or

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[2] Merriam Webster's Online Dictionary: http://www.merriam-webster.com/dictionary/capability, retrieved on 10/12/2008.

how entirely new concepts might need to be applied.

2.3.1. Communication

Capabilities in the area of *communication* are fundamental for metaverse technologies, as they are for any environment that needs to support collaboration. Capabilities related to communication are: feedback, multiplicity of cues and channels, language variety, channel expansion, and communication support.

The need for immediate feedback, multiplicity of cues and channels, and language variety has been a long-standing tenet of media richness theory (Daft and Lengel, 1986). It is worth examining how avatar-to-avatar communication relates to these concepts. Although the relevance of media richness theory to advanced communication technologies has been questioned (Burke et al., 2001), its constructs continue to be used in later theory development (e.g., media synchronicity theory), and we include them here not only because of their long history in media studies but because of the potential to reinvigorate these concepts in a new environment.

The capability of channel expansion incorporates experiential factors to show how seemingly fixed characteristics of media can be perceived differently by different people or by the same person over time (Carlson and Zmud, 1999). Key constructs from channel expansion theory that we expect to relate to metaverses are knowledge and experience, both relating to the comfort (based on experience) and commitment of technology users. Knowledge and experience may also matter in relation to the continuing use of the metaverse. The model of technology adoption by groups suggests that the complexity of a technology will negatively affect a group's attitude toward a particular technology and, thus, overall adoption or use of the technology (Sarker et al., 2005). For example, if users are not knowledgeable or experienced with the technology, they may resist using it. The concept of communication support comes from task-technology fit theory and is broadly defined as any aspect of a technology that supports, enhances, or defines the capability for a group to communicate (Dennis et al., 2001, Zigurs and Buckland, 1998). Specific elements of communication support include synchronicity, anonymity, feedback, and group display. In metaverses, these same capabilities may be implemented, but in different ways from those in current collaboration technologies.

Table 2 provides a starting point for understanding technology capabilities in metaverses related to communication. The table shows each potential capability, its definition and theory source, how each element is supported in current collaboration technologies, and how each element is or could be implemented in a metaverse.

2.3.2. Rendering

Rendering is the process of creating or executing life-like images on the screen and it is supported by the capabilities of personalization (Daft and Lengel, 1986) and vividness (Steuer, 1992). Personalization is the extent to which a technology allows for a personal focus among people (Daft and Lengel, 1986). People control the rendering of their avatars and can personalize avatar appearance; they can also have a personal focus through direct contact with other avatars. Whether personal focus or direct contact is the same in a metaverse as in face-to-face environments is yet unanswered, but since avatars can have direct contact with each other, this capability is relevant for metaverses. Vividness is defined as the richness of a mediated environment in terms of formal features (Steuer, 1992). Metaverses offer a synthetic rendering of natural or imagined environments and in a vivid manner visually recreate complex physical spaces (Blascovich et al., 2002). Table 3 provides a starting point for understanding technology capabilities for rendering.

2.3.3. Interaction

Interaction in a metaverse is supported by the capabilities of interactivity, mobility, and immediacy of artifacts. Research on telepresence and the concept of interactivity in synthetic environments supports the importance of interaction, and many of these capabilities are unique to metaverse technologies. Interactivity is defined as the extent to which users can participate in modifying the form and content of a mediated environment in real time (Steuer, 1992). Mobility is the extent to which

Table 2: Technology Capabilities for Communication in Current and Metaverse Environments				
Capability	**Definition**	**Current Theory**	**How capability is supported in current collaboration technologies**	**How capability is, or could be, implemented in a metaverse**
Feedback	Ability of medium to provide immediate feedback (Daft and Lengel, 1986)	MRT	- Face-to-face text or voice chat - Face-to-face video with communication of facial expressions - Synchronous communication	- Avatar-to-avatar text or voice chat - Avatar-to-avatar video with communication of facial expressions, body language, and gestures - Synchronous communication
Multiplicity of cues and channels	Ability of medium to transmit multiple cues, e.g., body language, voice tone, inflection (Daft and Lengel, 1986)	MRT	- Facial expressions in video - Tone of voice in video or audio	- Facial expressions, body language, and gestures of avatar in video - Tone of voice in video or audio chat - Rendering of people through manipulation of clothing and appearance of avatars
Language variety	Ability of medium to support large pool of language symbols to convey wide range of ideas and emotions (Daft and Lengel, 1986)	MRT	- Natural language - Internet language in text chat (e.g., LOL)	- Natural language - Internet language in text chat (e.g., LOL) - Voice manipulation
Channel expansion	Enhanced perceptions of media characteristics based on experience with channel, messaging topic, organizational context, and participants (Carlson and Zmud, 1999)	CET	- Training programs offered outside of context - Training offered with tutorials, help toolbar, or FAQs	- Training programs offered outside of context - Training offered with tutorials, help toolbar, or FAQs - Avatars must pass training on Orientation Island before joining
Communication support	Any aspect of technology that supports, enhances, or defines the capability of a group to communicate (Dennis et al., 2001, Zigurs and Buckland, 1998)	TTF; FAM	- Synchronicity - Anonymity - Feedback - Group display	- Synchronicity - Anonymity - Feedback - Group display via 3 dimensions and manipulable objects

Note: MRT = Media Richness Theory; TTF = Task-Technology Fit theory; FAM = Fit Appropriation Model; CET = Channel Expansion Theory

Table 3: Technology Capabilities for Rendering in Current and Metaverse Environments				
Capability	**Definition**	**Current Theory**	**How capability is supported in current collaboration technologies**	**How capability is, or could be, implemented in a metaverse**
Personalization	Personal focus supported by a medium (Daft and Lengel, 1986)	MRT	- Face-to-face video, audio	- Avatar-to-avatar video including eye gazing and other deliberate actions, such as touching - Personalization and rendering of people through clothing and avatar appearance
Vividness	Richness of mediated environment as defined by formal features (Steuer, 1992)	Tele-presence theory	- Face-to-face video	- Sensory rich mediated environment - Multiple options for presenting information, including three-dimensional

Note: MRT = Media Richness Theory

Table 4: Technology Capabilities for Interaction in Current and Metaverse Environments				
Capability	**Definition**	**Current Theory**	**How capability is supported in current collaboration technologies**	**How capability is, or could be, implemented in a metaverse**
Interactivity	Extent to which people can participate in modifying form and content of mediated environment in real time (Steuer, 1992)	Tele-presence theory	- Ability to modify content by adding files, documents, or posting information	- Use influences form - Real time communication - Teleporting
Mobility	Extent to which people are able to move around in a quick and efficient way	None	- Ability to join multiple spaces at one time	- Teleporting - Flying - Ability to be in different locations
Immediacy of artifacts	Extent to which people can create visual artifacts in the form of text, images, pictures, three-dimensional models, or some combination thereof in real time	None	- Immediate creation of joint authored text in a shared editor or joint authored drawings in a shared whiteboard - Immediate importing of outside files	- Immediate creation/building of text, figures, three-dimensional models, images or some combination - Fast modeling or building - Immediate importing of outside files or objects - Software agents and the ability to leave persistent artifacts and avatars behind

avatars are able to move around in a quick and efficient way. In metaverses, this can be accomplished by the ability to fly or teleport to different locations. Immediacy of artifacts is the real-time ability of users (represented by avatars) to individually and/or collaboratively create and use in-world artifacts such as text, images, and three-dimensional models. Table 4 provides a starting point for understanding technology capabilities for interaction.

2.3.4. Team Process

The fourth area of capabilities relate to *team process* and consist of capabilities for process structure, information processing, and appropriation support (Dennis et al., 2001, Zigurs and Buckland, 1998). Current metaverse technologies do not directly offer these capabilities, but they can be provided through custom objects and tools that can be built via scripting. For example, a common tool used for information processing in collaboration technologies is a brainstorming tool. Figure 2 shows an example of a three-dimensional brainstorming tool built in a VW. The example highlights how the unique capabilities of a metaverse can be leveraged to provide a different way of approaching a familiar group activity.
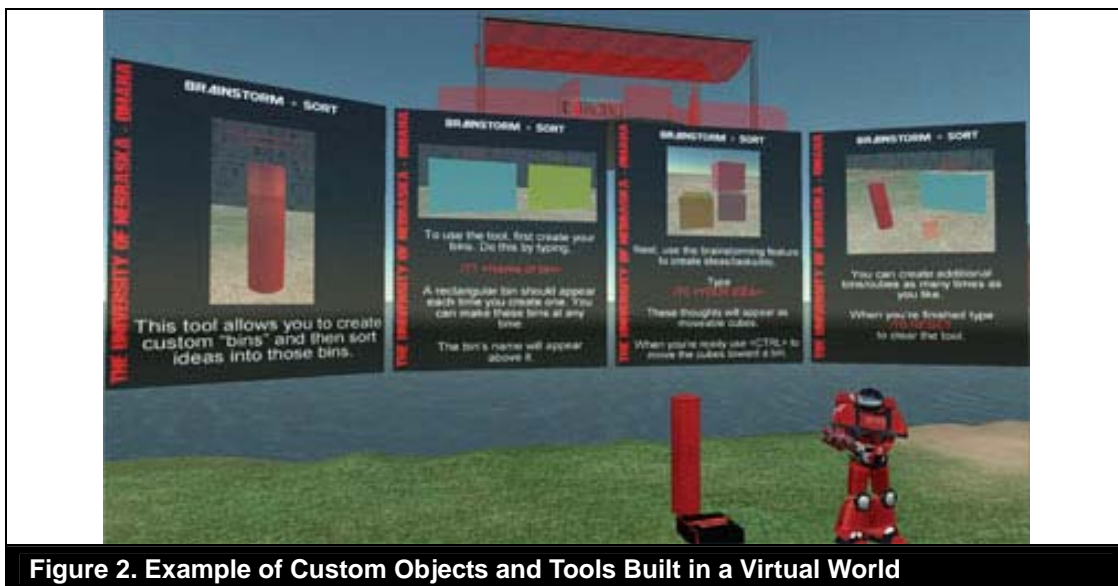

Figure 2. Example of Custom Objects and Tools Built in a Virtual World

Custom object and tool development can be done not only for brainstorming tools, but also for creating artifacts such as Gantt charts, critical path diagrams, and design documents. Table 5 provides examples of custom objects and tools that can be developed for capabilities of process structuring, information processing, and appropriation support.

Thus far, we have described three of the five components of our conceptual model (Figure 1), including the metaverse itself, people/avatars, and metaverse technology capabilities. The following section introduces the fourth component of behaviors, which occur through the interaction of people represented by avatars as they collaborate using metaverse technology capabilities.

2.4. Behaviors

Behavior in a metaverse is manifested through the interaction and communication of avatars. Prior research has shown that behaviors can affect individual performance, virtual team collaboration, and team outcomes (Jarvenpaa et al., 1998, Jarvenpaa and Leidner, 1999, Peters and Manz, 2007, Zigurs, 2003). It has been argued that behavior exhibited in virtual environments is different from behavior in face-to-face environments (Zigurs, 2003). We propose that behaviors exhibited in the context of a metaverse will be different because of the opportunities presented by the on-going use of metaverse technology capabilities.

Table 5: Technology Capabilities for Team Process in Current and Metaverse Environments				
Capability	**Definition**	**Current Theory**	**How capability is supported in current collaboration technologies**	**How capability is, or could be, implemented in a metaverse**
Process structuring	Any aspect of the technology that supports, enhances, or defines the interaction process for groups (Zigurs and Buckland, 1998)	TTF	- Person manually facilitating - Person taking meeting minutes to record the meeting	- The use of a software agent to lead a team - The use of a software agent to stand aside and record meetings and interactions with video
Information processing	Capability to gather, share, aggregate, structure, or evaluate information (Zigurs and Buckland, 1998)	TTF; FAM	- Brainstorming tools - Organization tools - Voting tools	- Three-dimensional brainstorming tools - Three-dimensional organization tools - Three-dimensional voting tools or games where avatars stand on their vote (e.g., move here for yes, move here for no)
Appropriation support	Support for appropriation provided by restrictiveness of the technology and outside factors (Dennis et al., 2001)	FAM; AST	- Face-to-face facilitation - Face-to-face training	- Avatar interaction for facilitation or leading - Avatar training using software agents

Note: TTF = Task-Technology Fit theory; FAM = Fit Appropriation Model; AST = Adaptive Structuration Theory

Metaverses provide the illusion that people are in the same space by removing physical boundaries and separation among avatars. Current collaboration technologies such as web conferencing, video conferencing, and video walls aim to provide an environment that emulates face-to-face communication; however, the technology still does not provide an experience that is equivalent to face-to-face. For example, video conferencing provides communication through what is commonly known as "talking heads" because of limitations in video representation. "Video walls" such as HP's Halo provide more life-size images and depth perception, but still present a boundary such as a wall or computer that separates individuals. In metaverses, the boundaries and separation no longer exist, since avatars interact with each other within the metaverse and not across boundaries. Metaverses allow both verbal and nonverbal cues to be rendered through the technology and controlled by the person behind the avatar. The ability to deliberately control cues that are typically near-automatic reactions in the physical world offers a new way for individuals to express behavior in metaverses.

Table 6 presents examples of non-verbal cues that can be expressed in a metaverse (Bailenson et al., 2002), by enabling the avatar to use a gesture or chat with Internet language such as emoticons and acronyms (Zitzen and Stein, 2004). For example, an avatar can shrug her shoulders indicating that she is unsure about an idea, or type an instant message that says "blushing" or "LOL" to indicate laughter. The avatar's behaviors are entirely separate from what the person might actually be doing in the physical world, e.g., the person may not be laughing at all.

Table 6: Non Verbal Cues in a Metaverse	
Type	**Example**
Gaze	Avatars can look at one another when chatting with either text or audio.
Head posture	Avatars can move their heads with deliberate actions representing body language.
Eye direction	Avatars can change the focus of their heads and specifically their eyes as they scan an island or move around a room.
Arm gesture	Avatars can take deliberate actions by clapping their hands including the sound of hands clapping.
Body posture	Avatars can change the posture of their body and include activities such as jumping, dancing, or flying.
Facial expression	Avatars can smile, frown, and represent other facial expressions.

Although there are many areas of behavior that may be relevant in a metaverse context, we are particularly interested in those that have the greatest likelihood to be impacted by technology as well as those that impact outcomes. Specifically, we are interested in behaviors related to the four areas of coordination, trust, role clarity, and shared understanding. We chose these specific areas because of their persistent importance in the literature of virtual teams (Dubé and Paré, 2004, Zigurs, 2003). Table 7 defines these four behavioral areas.

Table 7: Definitions of Behavioral Areas	
Behavioral Area	**Definition**
Coordination	The mechanism through which people and technology resources work together to carry out specified activities in order to accomplish stated goals (Grant, 1996, Khazanchi and Zigurs, 2005, Malone and Crowston, 1994)
Trust	A state involving confident expectations about another's motives and the willingness to act on the basis of the words, actions, or decisions of another (Boon and Holmes, 1991, McAllister, 1995)
Role Clarity	An understanding of individual roles within a team, including feeling certain about one's authority on the team, knowing one's responsibilities and knowing what is expected (Kayworth and Leidner, 2001/2002)
Shared Understanding	Mutual knowledge, beliefs, and assumptions that team members develop during the ongoing process of communication (Clark and Brennan, 1991, Khazanchi and Zigurs, 2005, Stahl, 2005)

Each of these areas represents a different set of behavior patterns. The sections that follow discuss each area both separately and in relation to other areas.

2.4.1. Coordination
The first behavioral area of interest in metaverses, especially concerned with working in virtual teams, is *coordination*. We define coordination as the mechanism through which people and technology resources work together to carry out specified activities in order to accomplish stated goals (Grant, 1996, Khazanchi and Zigurs, 2005, Malone and Crowston, 1994). Coordination is a critical area to understand in metaverses because it is a key factor for managing virtual work and can impact team outcomes (Khazanchi and Zigurs, 2005). Coordination may have multiple dimensions, e.g., geographic, temporal, task, and role coordination (Zigurs et al., 2001). With respect to the geographic dimension, coordination has been found to be a challenge when working across distance, time zones, culture, and technology (Massey et al., 2003, Zigurs et al., 2001). Successful temporal coordination in virtual teams is associated with higher performance, not in and of itself but through the behavioral interaction that results from coordination (Massey et al., 2003). Geographic and temporal coordination are particularly interesting in metaverses, in that metaverses break space barriers by allowing avatars to meet in-world and interact with each other.

While geographic coordination can be difficult, task and role coordination are also challenging for virtual teams (Horton and Biolsi, 1993, Katzy et al., 2000). Difficulties with task coordination and communication can prevent teams from sharing and managing knowledge that is critical to team performance (Katzy et al., 2000). In order for task and role coordination to occur, trust must be present (Jarvenpaa and Leidner, 1999). Lack of trust and the inability of team members to view each other make it hard to ensure that each member is working toward the same goal (Jarvenpaa and Leidner, 1999, Peters and Manz, 2007). In a virtual team, it can be difficult to ensure coordination without immediacy of feedback and the ability to view everyone's work.

We know that coordination can be accomplished via trust since trust is required to ensure that tasks and roles are understood and coordinated within a group (Jarvenpaa et al., 1998). Virtual team members must trust other group members to perform their tasks and roles accordingly so that team outcomes can be achieved. The following section elaborates on the concept of trust.

2.4.2. Trust

We define *trust* as a state involving confident expectations about another's motives and the willingness to act on the basis of the words, actions, or decisions of another (Boon and Holmes, 1991, McAllister, 1995). Jarvenpaa et al. (1998, p. 31) suggest that "trust is based on the expectation that others will behave as expected."

Trust is considered a critical success factor in achieving successful outcomes in both face-to-face and virtual teams (Jarvenpaa and Leidner, 1999, Zigurs, 2003), because it plays a role in all other areas – coordination, role clarity, and shared understanding. Trust helps reduce the uncertainty experienced in geographically separate and technologically based environments (Jarvenpaa and Leidner, 1999). However, trust is difficult to establish in virtual teams because of the lack of face-to-face interaction. Face-to-face interaction offers an opportunity for people to view others and understand a person through non-verbal behaviors. If what a person says is incongruent with non-verbal behavior, he or she may be more difficult to trust. But in virtual teams, non-verbal cues are often lost. In the absence of these cues and with time pressures on projects, teams often must establish swift trust (Meyerson et al., 1996). Swift trust develops when team members come together to accomplish a common task, but the team has a limited life span and trust is built on individuals' prior knowledge and experiences in similar situations. However, swift trust in virtual teams is fragile and difficult to re-build if compromised (Jarvenpaa et al., 1998).

Face-to-face communication is the ideal method of communication in many cases because it is helpful in establishing trust through verbal and non-verbal cues as well as human interaction (Jarvenpaa et al., 1998, Maznevski and Chudoba, 2000, Strauss and McGrath, 1994). However, non-verbal cues are hard to control in face-to-face communication since individuals usually do not think about the non-verbal cues they are displaying. The metaverse environment offers an opportunity to control one's non-verbal cues through the behavioral interactions of avatars that are controlled by people. People control both verbal and non-verbal cues, thus they can consciously interact and communicate in a way that is not possible in a face-to-face environment. This control can be used to establish trust but could also lead to non-trusting behavior since true feelings that would be expressed through non-verbal cues may be hidden in order to deceive others. Research regarding trust of software agents suggests that trust issues associated with online agents is complex (Wang and Benbasat, 2005). For example, users of software agents perceive human characteristics in relation to the agents, such as benevolence and integrity (Wang and Benbasat, 2005). This is an important point since our definition of a metaverse highlights the interaction of people as avatars with each other as well as software agents (Bainbridge, 2007). Furthermore, software agents may be particularly useful for implementing and running custom objects and tools in a metaverse.

2.4.3. Role Clarity

The third behavioral area of interest is *role clarity*. Roles represent the different functions an individual assumes in a virtual team, for example, a leadership role. Role clarity is defined as an understanding of individual roles within a team, including feeling certain about one's authority in a team, knowing one's responsibilities, and knowing what is expected (Kayworth and Leidner, 2001/2002). Role clarity

also includes knowing the expertise contributed by each individual on the team (Peters and Manz, 2007).

Leadership is an important role in any team. Leaders in face-to-face teams make their presence known by various non-verbal cues such as where they sit in meetings, body language, voice inflections and style of dress. However, many of these cues are lost in virtual environments (Zigurs, 2003). In the absence of leaders, the idea of self-directed teams has emerged (Jarvenpaa et al., 1998, Jarvenpaa and Leidner, 1999, Piccoli et al., 2004, Yoo and Alavi, 2004). Self-directed teams form based on the assumption that virtual teams will coordinate and be able to optimize their work (Powell et al., 2004). Due to the lack of direct control, teams are self-managed and empowered to make choices about their roles and behavior (Lee-Kelly, 2006). Team members begin to realize that in order to accomplish their goals, they must work together and take on different roles (Peters and Manz, 2007).

The clear definition of roles within the team can promote cooperation in working toward a common goal (Peters and Manz, 2007). For example, Linebarger et al. (2005) studied virtual product design teams in immersive virtual environments and found evidence to support distinct patterns of collaboration in terms of roles, including complementary, competitive, peer-to-peer, and leader-follower patterns. During group experiments, the authors found that "collaboration consists of fluid transitions between these patterns or roles in the accomplishment of the design task, driven by a flexible process of sub-grouping and regrouping which reflects the structure and progress of the task" (Linebarger et al., 2005, p. 1). However, it should be noted that members of virtual teams hold multiple roles that may be determined by the complexity and challenge associated with a team's task. The need for virtual members to adapt to multiple roles may lead to higher role conflict and role ambiguity (Rizzo et al., 1970). This issue needs further exploration in the context of metaverses.

2.4.4. Shared Understanding

The final behavioral area of interest is *shared understanding*. Shared understanding is defined as the mutual knowledge, beliefs, and assumptions that team members develop during ongoing communication (Clark and Brennan, 1991, Khazanchi and Zigurs, 2005, Stahl, 2005). Shared understanding also includes a common understanding of the strategic direction of a project (Liedtka, 1996). In order for team members to work together, they need a shared understanding of what they are working on, how they are going to work together, and who they are working with (Mulder et al., 2002). This understanding impacts interaction among team members and leads to the ability to leverage expertise, facilitate coordination, avoid duplication of effort, and realize a team's overall goals (Duarte and Snyder, 2001, Liedtka, 1996, Peters and Manz, 2007).

Shared understanding requires knowledge of the roles each team member plays and the expertise contributed by each (Peters and Manz, 2007). This understanding is reached through feedback, communication, and interaction among individuals (Mulder et al., 2002). Cultural differences, communication, and language barriers among team members can impact team effectiveness or impede feedback and interaction (Dubé and Paré, 2004, Kayworth and Leidner, 2001/2002, Maznevski and Chudoba, 2000). It is important for teams to find ways to overcome these differences, reduce uncertainty, and find ways to build shared understanding (Peters and Manz, 2007).

Shared understanding can be difficult to achieve in virtual teams because they comprise individuals from different disciplines, functions, geographies, and cultures. The challenge is one of creating opportunities for team members to have the meaningful communication and interaction that is necessary to overcome differences (Holton, 2001). Particularly important is the need to ensure that adequate time is devoted to creating shared meaning and commitment to a culture of collaboration (Holton, 2001). Shared language is also important, since it can promote more effective coordination and collaboration (Majchrzak et al., 2000).

Capabilities of metaverses can promote the development of shared understanding. The lack of physical boundaries provides an opportunity for avatars to interact with each other and provide immediate feedback, which promotes the development of shared understanding (Cramton, 2001).

Metaverses also have the potential to eliminate cultural barriers between individuals through the use of the Internet's universal language. Metaverses also offer the opportunity to demonstrate or show ideas with hand movements or gestures. For example, if someone is having a hard time understanding another person, his or her avatar may use non-verbal communication or arm movements to facilitate communication and get the point across. Finally, metaverses offer the ability for people to create a generic appearance, one that is independent of racial or cultural differences.

To this point, we have discussed four of the five components of our model. These five components contribute to the final component, namely, the outcomes or out-world artifacts that are produced as a result of work in a metaverse. The following section addresses this final component.

2.5. Outcomes

Outcomes are the final component of our model. Decades of research on groups and group effectiveness reinforce the importance of both task and team-related outcomes (McGrath, 1984), and a metaverse environment should be no exception. In the group literature, we see concern with outcomes such as perceived quality and group behavior (Gouran et al., 1978) and a variety of process-related measures (Green and Taber, 1980). Indeed, different models of group effectiveness recommend a multidimensional approach to assessing effectiveness. Hackman (1983), for instance, suggests that group effectiveness is a function of the multiple dimensions of task, the capability of group members to continue to work together, and contributions to personal growth and well-being. Time-Interaction-Performance theory also takes a multi-dimensional approach by emphasizing production (task performance), well-being (relations among group members), and member support (relation between individual members and the group) (McGrath, 1991). We include member support and perceived quality to encompass many of these traditional team outcomes. In our model, however, we choose to highlight distinctly different outcomes that may be unique to a metaverse environment, specifically: self image, cultural synchronicity, deception, intent to immerse, and reconnect anxiety. Table 8 summarizes the definitions of these concepts.

Table 8: Definitions of Outcomes	
Outcome	**Definition**
Member Support	Relation between individual members and the group (McGrath, 1991)
Perceived Quality	Perception of the quality of group outcomes (Gouran et al., 1978)
Self Image	Way in which one views oneself, both physically and emotionally
Cultural Synchronicity	Extent to which people are aligned in their perceptions of others' cultural characteristics
Deception	Presenting false information (e.g., Biros et al., 2002, Biros et al., 2005, Donath, 1999)
Intent to Immerse	Behavioral intent to engage with a virtual environment (Davis, 1989, Guadagno et al., 2007)
Reconnect Anxiety	Withdrawal effect experienced by individuals who have become so engaged in a virtual world that they prefer the virtual world to the physical world

Self image is unique to metaverses because it can be controlled in a different way than in face-to-face teams or "traditional virtual teams," i.e., virtual teams using non-metaverse environments. Self image in a metaverse might change as a result of self efficacy or the capabilities that are provided by the metaverse technology. For example, physically and emotionally, how you look (including gender swapping) and what you do (including flying) in a metaverse can be drastically different from the physical world. How this self image does or does not change is interesting for speculation, both as an outcome and in terms of how it feeds back into the metaverse environment to affect on-going behaviors and uses of technology capabilities.

We introduce the term cultural synchronicity to mean the extent to which people are aligned in their perceptions of others' cultural characteristics. How does the metaverse environment and

people/avatar representation impact cultural perceptions of team members? While there is no reason to expect that diverse avatar appearances will increase or reduce cultural barriers and their impact on areas such as coordination and shared understanding, there is an opportunity for cultural differences to be reflected in this environment. Not only can avatars represent different ethnic cultures, but they can represent different societal subcultures through dress or appearance. Does the metaverse promote an environment of cultural synchronicity, or does it serve to exaggerate cultural and societal differences? These are important questions that are unique to an environment where cultural clues can be manipulated easily and quickly.

The outcome of deception is not a new concept to virtual teamwork (e.g., Biros et al., 2002, Biros et al., 2005, Donath, 1999). This outcome is a concern not only in relation to people/avatar representation in metaverses, but also in relation to roles and the portrayal of one's abilities. Just as with cultural clues, metaverse technology capabilities provide easy and unique opportunities for deception.

The outcomes of intent to immerse and reconnect anxiety relate to the technology itself. Rarely do we see outcome measures relating to the technology on which virtual teams rely, so this is an area where contributions can be made. Intent to immerse combines the immersion concept with the behavioral intent to accept technology (Davis, 1989). Based on prior experience within a VW, how willing are people to re-immerse themselves in that world? Related to that concept is the idea of reconnect anxiety, which could measure withdrawal effects for individuals who have become so immersed in a VW that they would rather be in the virtual rather than physical world.

We can speculate that the ultimate performance of a team would be the *union* of several things and may be quite different from how we have defined performance in either face-to-face teams or "traditional virtual teams," i.e., virtual teams using non-metaverse environments. In addition, we may want to measure the path to outcomes in a flexible way, recognizing that there is no one "best" path, as team members use and choose different bundles of technology capabilities in a dynamic and flexible way throughout the life of the team. Each of the behavioral areas discussed in previous sections is expected to impact outcomes, and the outcomes then feed back to the metaverse and what takes place in-world.

3.   Propositions from the Model

The model can be used to generate propositions, either within or across the areas and at either the individual or group level. The model is built on an interactionist, socio-technical view, which means that on-going social interaction affects and is affected by technology capabilities, and emergent use ultimately affects outcomes. This interplay recognizes the role of human actors through their avatars and the multiple potential paths that their interaction can take. This section presents examples of propositions that highlight key effects from the model. The examples reflect both individual and group levels of analysis, as well as relationships between individual areas and across multiple areas of the model.

The first example relates metaverse technology capabilities of communication to trust, and it is stated at the individual level, since it addresses trust development between and among team members:

> **Proposition 1:** *Metaverse technologies provide initial capabilities for communication among virtual team members, and on-going use of those capabilities affects and is affected by the level of trust among team members.*

This proposition could be elaborated through development of specific hypotheses that examine unique aspects of communication capabilities in metaverses and how they shape and are shaped by trust in virtual teams. These unique aspects include the use of head-to-toe visual communication among avatars, video and audio chat among avatars, and the communication of deliberate body language, gestures, and other non-verbal cues. In traditional face-to-face communication, people often cannot control their body language or gestures in response to conversations, at least not in the deliberate way that they can in metaverse environments. We would expect these capabilities to be

particularly useful for building trust, when used with the intent to do so in a positive way, though they can also be used to deceive. Thus, both positive and negative uses of these capabilities must be examined. Specific hypotheses related to language variety, Internet language or slang, and communication support in metaverse technologies could yield interesting findings on the particular dynamics by which people use and adapt specific aspects of communication capabilities.

The second example relates the development and use of custom objects and tools for team support with coordination, stated at the group level:

> **Proposition 2:** *Metaverse technologies provide initial capabilities for virtual team members to develop and use custom objects and tools for team process, and on-going use of those capabilities affects and is affected by a virtual team's coordination.*

Custom objects and tools implement capabilities of process structure, information processing, and appropriation support, e.g., agenda setting, agenda enforcement, facilitation, and recording. These capabilities can be built by avatars in a VW and run or implemented by software agents. For example, robot avatars can be placed in areas for recording avatar meetings, or repositories can be built for gathering, aggregating, evaluating, and structuring information. Specific hypotheses could examine how team coordination develops when tools for process structure and idea evaluation are controlled and created and modified by the avatars (people) themselves.

The third example relates combined technology capabilities to role clarity and is stated at the individual level of team member roles:

> **Proposition 3:** *Metaverse technologies provide initial capabilities for communication, interaction, and rendering, and on-going use of those capabilities affects and is affected by the role clarity of virtual team members.*

It can be argued that the overall nature of a metaverse offers an environment where leadership and leader roles may be easier to express than in traditional collaboration technologies. In a metaverse, team members can interact and provide immediate feedback on behavior and the delivery of artifacts. Leaders can emerge through the use of verbal and non-verbal cues that can be deliberately expressed. People can control their avatars, which means they can control their placement in meetings, whether they sit or stand, where they sit, and who they sit next to. They can also control their body language and style of dress. All of these possibilities suggest opportunities for leadership emergence in a way that is unique to metaverse environments and that takes advantage of combined capabilities.

The fourth example relates combined technology capabilities to shared understanding and is stated at the group level:

> **Proposition 4:** *Metaverse technologies provide initial capabilities for communication, rendering, and interaction, and on-going use of those capabilities affects and is affected by a virtual team's shared understanding.*

The interaction capability in a metaverse presents a real shift from traditional environments and, in combination with communication and rendering capabilities, the VW environment offers more than current collaboration technologies. The very idea of a group or team level shared understanding may be different from what we have been able to achieve so far, e.g., teams could develop a "collective mind" wherein individual team members understand how their effort contributes to the virtual team as a whole (Crowston and Kammerer, 1998). That abstract concept can be rendered visually in the three-dimensional space, making shared understanding not just concrete but visually manipulable by team members.

The final example relates metaverse capabilities to outcomes:

> **Proposition 5:** *Virtual world outcomes result from a complex process of on-going interaction of avatars and their behaviors with metaverse technology capabilities.*

This proposition is stated at the most general level, to capture and reinforce the underlying philosophy

of the model, the interactive nature of the components, and the emergent and non-deterministic nature of the process. Two examples serve to highlight this point.

Metaverse capabilities include the concepts of "immediacy of artifacts," "information processing," and "mobility." Custom objects and tools can be built for information processing-related artifacts such as Gantt charts that are common in virtual teams, and the immediacy of artifacts capability means that team members can develop and upload "physical" models quickly and cheaply. The combination of these capabilities enhances the spirit of the technology while potentially adding structural features that did not exist before. This is clearly an interesting aspect of metaverses that is not easily tailorable in other collaboration environments, and this complex interplay will affect outcomes through a variety of paths.

A second example from the area of team process is the idea of brainstorming, an example of which was shown in Figure 2. This example raises numerous questions for other areas of the model. How do we need to modify these kinds of processes in order to enhance virtual team performance and outcomes in metaverses? How will three-dimensional representation and visualization of information contribute to optimizing divergent tasks like brainstorming? Can this, in turn, reduce information overload? How do different combinations of capabilities affect intent to immerse or reconnect anxiety? We have shown how the model can be used to generate high-level propositions at individual and group levels, and between single and multiple areas of the model. The specific capabilities within each area, as noted in the examples, provide ample opportunity for development of hypotheses to examine the general propositions in more detail.

4.   Challenges and Opportunities

Figure 1 presented our conceptual model as a foundation for exploration and research on virtual teams in metaverses. The example propositions developed from the model serve as a starting point, and further development and refinement of these ideas can yield testable hypotheses. This section discusses challenges and opportunities based on the conceptual model, with a focus on identifying key research areas in this domain that have the greatest potential for initial impact.

4.1. Metaverse Design

A significant amount of further study is needed on the design and architecture of metaverses, including both software and hardware. Of particular interest is the architecture of metaverse technology that uses peer messaging protocols to deliver VW environments to users, as opposed to the traditional server-based configurations that are becoming increasingly unwieldy as more users join. Another aspect already under development is the ability of people to port their avatars seamlessly among different types of metaverse environments (Naone, 2008). This capability would significantly enhance use of such environments by allowing team members to present a consistent appearance in different work environments.

More experience with metaverse environments will help to suggest additional design features. For example, a specific VW might offer the ability to "pass notes" from one avatar to another avatar, but may not offer a specific built-in document storage capability. Is this a capability that virtual team members need, or is it better to have document repositories as a custom object and tool or to maintain documents outside of the VW? This interplay of features needed in the world and tasks supported outside the world is an important design consideration.

Our framework addressed the question of technology capabilities across the four areas of communication, rendering, interaction, and team process. That framework can be used to address timing questions like that of Carte and Chidambaram (2004, p. 449) in the context of existing technology: "When should different collaborative technology capabilities first be utilized by a group?" The framework can also be used to identify new capabilities in each area. For example, what additional metaverse technology capabilities have an impact on communication? Interviews or focus groups with existing metaverse users could provide an understanding of the aspects of each area that are yet unknown. Our own recent experimental work has shown that VW inhabitants are eager to

participate in interactions that reflect on and expand their experiences.

A final challenge related to the design of metaverses is the need to better understand how these environments change team members' perceptions of virtuality and presence. A common factor in the research on virtual teams is the strong dependence on technologies to link the team and its tasks. Metaverses have potential to change long-accepted ways of working and interacting, both positive and negative. The challenge is to understand what is different as well as the relationships to foundational theories that have guided our thinking about virtual teams in the past. At a minimum, this work can provide the basis for developing enhancements to current theory, while also suggesting areas for developing new theory.

4.2. Participation

The topic of participation in VW environments deserves further exploration. In particular, we need a better understanding of how people use the capabilities of metaverses. What factors impact how people determine what their avatar will look like and who they will be in a VW? How does the ability to mask or make anonymous a person's out-world persona, gender, or culture impact interaction and trust? We argued that the ability for avatars to interact with each other and to provide immediate feedback on the behavior of others is unique in this environment and can serve to enhance coordination. Future research is needed to determine how individuals use specific metaverse technology capabilities to improve participation and interaction.

Leadership and leader roles are an important area of study in this context, given that a metaverse offers the ability to interact and provide immediate feedback on behavior and delivery of artifacts. Leadership emergence and role assumption can be studied through easier manipulation of cues that are associated with leader behavior and appearance. Is there a new set of cues that relate to metaverse technology capabilities that leaders can take advantage of to influence others? For instance, leaders might look and behave differently in terms of dress, language style, use of slang, responsiveness to questions, interaction style, and position in relation to members. How do leaders emerge in a VW? Do the style of dress, avatar appearance, and individual behavior have an impact on who is identified as the leader in the group?

As organizations become more project-oriented, metaverses may present an opportunity to have more leaders, which may lead to improved efficiency (IBM, 2007). Previous research has suggested that leadership in virtual teams is a shared responsibility among team members (Zigurs, 2003). The study of players in online games has shown that leaders shift roles and leaders who do emerge are sometimes the least expected ones (IBM, 2007). Those studies suggest that leadership is not based on out-world appearance or political climate, but rather on the ability of a team member to lead the team. Metaverses offer the same potential for leadership. For instance, when people are not interacting face-to-face, they do not need to worry about traditional practices of trying to impress the right people.

Metaverses can play a training and development role as well as provide a shared working environment for virtual teams. As training and development sites, metaverses could be used to develop teams and team leaders. For example, many organizations have embraced metaverses for learning and simulation. Metaverses have the potential for improved understanding and brainstorming through the technology capability of immediacy of artifacts. Best practices for knowledge sharing and information exchange can be explored with the ability to demonstrate ideas and understanding in three-dimensional space. Metaverses provide the visual learning component that is missing in traditional virtual team interaction and knowledge sharing. Further, role playing can be used to train and develop skills of teams. For example, decision environments can be established and avatars can role play what the right steps would be for the specific situation.

Finally, one of the major challenges in teamwork is the ability to move from an individual contribution to a synergistic product. We do not know how the group attitude or group outcome may change or be enhanced in a metaverse. How do metaverse environments impact group attitude and help to build

group outcomes that are synergistic? This question is particularly interesting given the ability to build three-dimensional representations of artifacts during the course of group interaction, including representations of opinions within the group.

4.3. Research Design

Researchers of social systems have always grappled with significant methodological challenges, and the conduct of research in metaverse environments is no exception. Those problems can generally be categorized as 1) the trade-off between scientific control and realism, 2) an inability to adequately replicate previous studies, and 3) access to representative sample populations.

Blascovich et al. (2002) argue that researchers have been building VWs in traditional lab experiments for years, especially with the use of sophisticated software to create and control experimental conditions. Today, researchers can use the advanced graphical and scripting capabilities of metaverses to create virtual buildings, machines, and even "people" with whom to interact (Bainbridge, 2007). A researcher can choose exactly which aspects of a situation should be included (i.e., controlled) while providing highly-realistic detail. The data capture features inherent to metaverses facilitate detailed analysis of complex interactions that can reveal insights into what actually transpired during experiments, allowing for more realistic conclusions (Schroeder et al., 2006). Once a specific environment is crafted, the scenario can easily be re-instantiated to allow quick, low-cost replications (Bainbridge, 2007). The scenario can also be shared with other researchers, allowing them to replicate experiments precisely (Blascovich et al., 2002) and build more generalizable results.

Millions of people are using VWs, which dramatically opens recruitment of potential subjects for metaverse experiments. Higher participation and more representative samples increase statistical validity and further bolster the ability to draw generalizable conclusions from experiments. However, there could be challenges related to approval by institutional review boards for studies in VWs, similar to challenges for other studies that use anonymous subjects. With avatars, for example, it may not be possible to verify whether subjects meet adult age requirements, which has implications for human subject and ethical considerations in the design of tasks and experiments.

4.4. Measurement

There are a number of challenges and opportunities related to measurement strategies for metaverse environments, including data collection. The synchronous nature of work in metaverses makes it relatively easy to collect data on team and meeting behaviors. Measures can be captured from a variety of sources, including surveys, video, built artifacts, still images, and text chat. Unique listening devices can be created and placed in locations where virtual team members meet to hold conversations for unobtrusive recording. Thus data capture in metaverse environments provides a broader set and variety of techniques, which also increases opportunities for triangulation and the potential for a unique synthesis of different measures. For example, perceptions can be measured through surveys and triangulated with video and artifact creation and use.

Whether or not new measures are needed in a metaverse environment remains an open question. For example, presence concepts have been measured in different ways using a variety of instruments (e.g., Bailenson et al., 2005, Biocca and Harms, 2002, IJsselsteijn et al., 2000, Kalifa and Shen, 2004, Kaushik et al., 2002, Kreijins et al., 2004, Nowak and Biocca, 2003, Romano and Brna, 2002, Schloerb, 1995); however, systematic examination in a metaverse context still needs to be done. If, indeed, the environment provides unique synthesis of existing ideas or entirely new constructs (such as "collective mind" for shared understanding), this provides a good opportunity for development of new measures, as do the outcomes that we have identified.

4.5. Virtual World Use and Adoption

We believe there are fundamental differences between metaverses and other collaboration technologies that can have impacts on virtual team outcomes, both positive and negative. For

example, metaverses offer richer interaction capabilities and can potentially help overcome the challenges related to geographic dispersion, yet there is a high learning curve associated with metaverse technology. This higher learning curve may lead to difficulties in managing varied technology proficiencies in a team. The development of client-side, peer-to-peer platforms for VWs may make this a short-term challenge, but the ease with which people enter and become comfortable in VWs is an important topic for study. The synchronous nature of avatar interaction also creates restriction and scheduling difficulties, though there are interesting possibilities for seeing how artifacts might be used for handing-off interim tasks asynchronously.

Several challenges inherent to metaverses may slow their use and adoption for virtual teams. As noted, most VWs have a high learning curve for those unfamiliar with 3-D environments. There may be resistance to taking the technology seriously because of the association with gaming. Within the environment itself, the very richness of the activities and appearance of surroundings means that there are distractions. Virtual team members may also find it difficult to balance in-world activities with out-world ones. One example is the norms of behavior and culture, where teams that operate in-world might develop quite a different culture or find it difficult to carry over an organizational culture into the virtual environment. This point is important in that most teams do not operate as purely virtual or purely face-to-face teams, but work together in arrangements that are a blend of virtual, face-to-face, or hybrid models of team interaction. Therefore, it is important to further investigate how teams balance in-world and out-world work as well as what tasks are amenable to metaverse technology capabilities and what tasks are not.

A final challenge for metaverses relates to their adoption and diffusion in everyday use. Some managers and researchers consider group decision support systems a failure because they did not achieve widespread adoption within organizations. Are metaverses likely to experience the same fate? One fundamental difference makes a comparison difficult. Unlike group decision support systems, VWs are user-designed environments that are not tied to a specific process or approach. Thus, VWs present a relatively blank slate on which users can create their own worlds, and with greater ease and variety than previous kinds of environments. The opportunity to interact in realistic three-dimensional environments that support team communication is also an important difference, because this adds a visual and personal component.

Similar to other collaboration technologies, we do not presume that VWs will replace existing tools, such as the ubiquitous use of email, but will supplement those tools. The challenge, then, is to determine which situations are appropriate for utilizing metaverse technology capabilities and where they can make a substantive difference. Specific implementations of VWs will be replaced and new ones will appear, as the marketplace continues to change. But the fundamental capabilities offered by metaverse environments, as developed in our conceptual model, provide a foundation that allows for evolution and change in a way that preserves continuity of underlying concepts.

5.   Conclusion

Our overall goal was to enhance research and practice in virtual teams in the context of metaverses through the development of a conceptual model that can be used to generate propositions and hypotheses across a range of key concepts. We presented a set of challenges and opportunities for future work. This foundational work is intended to contribute to a deeper understanding of virtual collaboration and teamwork in traditional contexts by initiating the process of increasing understanding of opportunities and risks that are available with metaverse environments. We have described a theoretically-defined set of technology capabilities as well as behaviors that illustrate how metaverses are unique collaboration environments and how that uniqueness can be taken advantage of in virtual teams. Finally, this work provides a way forward for researchers and managers interested in understanding and studying the metaverse technologies.

Members and managers of virtual teams have much to discover with respect to this new environment and the potential for new practices. For some companies, the initial question of why a VW presence might be needed for their organization has been answered by market pressures. Some organizations

have a VW presence simply because their competitors are doing it, a phenomenon that mimics the early days of the Internet. A presence often started out as merely informational or for the purpose of branding. The model and concepts presented in this paper can point to areas where managers and members of virtual teams can focus their attention.

Virtual teams continue to face challenges with communication, interaction, and technology limitations. The specific capabilities of metaverse technologies offer ways to address these challenges. Rather than continuing to seek the ephemeral goal of simulating face-to-face interaction across distributed sites and contexts, VW designers and users can use metaverse capabilities for thinking creatively about interaction and collaboration. For example, immediacy of artifacts creates quick and concrete interim results over the course of completing a team deliverable. A sensory-rich environment, combined with the capability to manipulate avatar appearance and gestures, has potential to enhance team-building and cohesiveness. Training and interventions for enhancing team process can be done in-world, taking maximum advantage of these advanced capabilities. However, positive outcomes are never guaranteed, as highlighted in the discussion of unique outcomes. Metaverses present a new environment for organizational roles, behaviors, and expectations. Managers should not assume that people will behave and look like their real world counterparts in these environments. Teams in these environments should not be managed just like traditional virtual teams, as the people and behaviors may be fundamentally different, potentially creating tensions and new behavioral scripts between the two worlds. The concepts presented here point to multiple directions for future examination and use of this phenomenon.

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Appendix A: Background on Metaverses

Metaverse environments are built on client-server architectures. People typically join a specific virtual world by installing customized client software on their local machines and connecting to servers that allow them to exchange information with the VW and other participants. Early versions of VWs were largely text-based, and interaction was restricted to text-based chat messages. Current versions of VWs provide vivid, synthetic spaces where people can interact in increasingly realistic ways and design their surroundings in whatever way they can imagine.

Linden Lab's Second Life (http://www.secondlife.com/) is currently one of the most visible instances of the phenomenon of metaverses. As of January 2007, over three million residents had registered on Second Life (Ives and Piccoli, 2007). One year later, Second Life had grown to over 12 million residents (Linden, 2008). Numerous organizations have tested Second Life's viability as a commercial and collaborative environment, including IBM, Sears, Circuit City, Toyota, Mazda, Dell, Sun Microsystems, MTV, Adidas, MLB, STA Travel, and NASA (Brandon, 2007, Holden, 2008, Ives and Piccoli, 2007). Other examples of VWs include IMVU (http: www.imvu.com), There (http://www.there.com/), Active Worlds (http://www.activeworlds.com/), Kaneva (http://www.kaneva.com), and the peer-based messaging protocol based system, Cobalt (http://croquetproject.org/index.php/Cobalt).

Joining a VW usually entails creating a named account and an avatar that will represent an individual person (Ives and Piccoli, 2007). VWs typically provide "stock" avatars to help people get started, but people can modify their avatar's appearance to create dramatically different representations. Figure 3 shows examples of avatar representations that were built in Second Life.

Figure 3. Examples of Avatars Built Within Second Life

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